PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVII, No. 6, pp. 159-176 July 30, 1951

RELATIONSHIPS OF THE PELAGIC SHARK EUPROTOMICRUS BISPINATUS, WITH DESCRIPTION OF A SPECIMEN FROM OFF CALIFORNIA*

BY

CARL L. HUBBS and J. L. McHUGH†

On the night of November 19, 1948, while fishing with a dip-net under a surface light at 34° 57′ N. Lat., 131° 30′ W. Long. (nearly 500 nautical miles off the nearest point of the California coast), in a region where the ocean depths are indicated as ranging between 2,400 and 2,800 fathoms, the junior author and Robert P. Huffer captured a pelagic shark (plates 4–6) that was cruising slowly at the surface. Its small size, slender and cylindrical form, subconic head, round and unprotected eyes, scarcely upturned caudal axis, smooth contours, very slimy skin, almost uniformly blackish color, except on the clear outer parts of the fins, and its very small gill slits gave it an appearance that was distinctly unlike that of most sharks and that was somewhat suggestive, superficially of course, of a lamprey.

We owe thanks to Dr. Léon Bertin of the Muséum d'Histoire Naturelle, Paris, for measurements of the type specimen of *Scymnus bispinatus* Quoy and Gaimard, and to William C. Schroeder of the Museum of Comparative Zoology of Harvard University and W. I. Follett of the California Academy of Sciences for assistance in processing literature.

* Contributions from the Scripps Institution of Oceanography, New Series, No. 522. Manuscript received December, 1950.

† Scripps Institution of Oceanography (University of California), La Jolla, California. Since the paper was written, the junior author has become Director of the Virginia Fisheries Laboratory, Gloucester Point, Virginia.

IDENTIFICATION OF SPECIMEN AND STATUS OF THE GENERA EUPROTOMICRUS AND SQUALIOLUS

On study the specimen (California Academy of Sciences, No. 20431), a female 233 mm. in total length, is identified with *Euprotomicrus* Gill, a squaloid genus referable to the family Dalatiidae (Scymnorhinidae) as currently recognized. It is clearly conspecific with the hitherto unique type of *E. hyalinus* Eigenmann (1893 : 35), which was also collected in the open Pacific between Hawaii and California, but nearer Hawaii. That specimen was destroyed in the San Francisco fire. The one at hand is the only extant example of the genus known from the Pacific Ocean and, so far as we know, the only one in an American museum.

It seems highly probable that *E. hyalinus* is identical with *E. bispinatus* (Quoy and Gaimard). Garman (1913 : 235) doubted its distinction and Fowler (1941 : 265) synonymized it with that species. The obviously pelagic habitat of *E. bispinatus* and the wide temperature difference between its known areas of occurrence suggest that it is a widely ranging species. In addition to the two known localities in the northeastern Pacific, the record stations for *E. bispinatus* comprise the islands of Mauritius (Île de France) and Bourbon (Réunion) in the Indian Ocean and Campbell Island, far south of New Zealand (see synonymy by Fowler). The New Zealand record (references in Phillipps, 1927 : 10) seems to have been in error, according to evidence later presented by Phillipps (1928 : 224–225).

The new specimen does differ in certain respects from the only generally available recent description of *E. bispinatus*, namely Fowler's. Though this author attributed his redescription to Quoy and Gaimard (1824 : 197, pl. 44, figs. 1–2), an examination of the original description shows that Fowler must have based his account, including measurements, largely on the rather crude figure (which was reproduced in outline by Phillipps, 1928, fig. 5), and must have used methods of measurement different from those we adopt.

Fowler's indication that the pectoral extends half way to the first dorsal in the type was obviously drawn from the main figure, which must be in error. That this fin in the type as well as in our specimen extends less than one-third the distance to the origin of the first dorsal is indicated by the size of the fin shown in the ventral view in the type figure, by measurement of a topotype given by Müller and Henle (1841 : 95) and, conclusively, by remeasurements of the holotype made for us by an assistant to Dr. Léon Bertin in accordance with our specifications.

Confusion was also encountered in regard to the position of the first dorsal fin, but again the full evidence fails to confirm suggestions of a specific difference. In his purported restatement of the original description, Fowler wrote "first dorsal inserted midway between snout tip and caudal

base" (which would indicate an approach toward *Squaliolus),* but the figure shows the position midway between snout tip and the end of the caudal fin. Our specimen has the fin inserted even farther back, midway between the tip of the caudal and the middle of the eye. Duméril (1865:457), who had three specimens, indicated the dorsal origin as "située un peu en arrière de la première moitié de la longueur totale." Fortunately, the type is extant. Dr. Bertin's measurements (p. 170) indicate that the origin of the dorsal in the type is essentially as in our specimen. He has also compared a copy of our figures with the holotype of *E. bispinatus,* and concurs in the view that *E. hyalinus* is probably a synonym of *E. bispinatus.* Accepting this view, we treat *Euprotomicrus,* like most related genera, as monotypic.

Garman (1913:234), Bigelow and Schroeder (1948:500), and Fowler (1941:264) synonymized *Squaliolus* with *Euprotomicrus,* but in our opinion the generic separation is fully justified, even in a conservative concept of the genus. *Euprotomicrus* differs from *Squaliolus,* as described by Smith and Radcliffe *(in* Smith, 1912:683–685, fig. 4, pls. 50 and 54), in the following respects:

(1) The total lack of the first dorsal spine. To forestall any thought that the name *bispinatus* suggests dorsal spines in the type species of *Euprotomicrus,* we point out that this name obviously was derived from the spiny process on each pelvic fin of the male holotype.

(2) The more posterior origin of the first dorsal fin, which is much nearer the insertion of the pelvic than that of the pectoral fin, rather than the reverse, and is well behind instead of well before the middle of the total length.

(3) The more reduced size of the first dorsal fin. The base of this fin is less than one-thirtieth, instead of more than one-twentieth, the total length.

(4) The less excessively elongated second dorsal base, which is less than one-fourth, instead of nearly one-half, the interspace between the origins of the paired fins. The dorsal base does not overlap the pelvic base, as it does in *Squaliolus.*

(5) The rounded rather than pointed caudal lobes.

(6) The thickly rounded rather than pointed snout, in both side and top views.

(7) The smaller head. The head length is about one-fifth rather than one-third the total length.

(8) The longer mouth grooves, in lateral projection about two-thirds rather than one-third the preoral length.

(9) Probably also in dentition: the upper teeth are arranged more in quincunx than in the straight rows that were figured for *Squaliolus* and the lower teeth have the crowns in full contact basally, instead of being separated by the outer shoulders of the bases, as figured. Each of these

shoulders, in consequence, lies wholly on the base of the next outer tooth.

A third species, *Squaliolus sarmenti* de Noronha (1926), from Madeira, has been referred to *Euprotomicrus* (Maul, 1949: 139), but obviously should be retained in *Squaliolus*. In fact, there seems to be no valid ground for separating *S. sarmenti* from the Philippine species *S. laticaudus*. The first dorsal fin was indicated as being somewhat more posterior, but on comparing the photographs and considering the distortion of the preserved specimens, we fail to appreciate the distinction. Consequently, we synonymize *S. sarmenti* with *S. laticaudus* and thus reduce *Squaliolus*, as well as *Euprotomicrus*, to monotypic status.

That *Euprotomicrus* and *Squaliolus* should be treated as monotypic, along with most of the related genera as currently recognized, need not cause concern to a conservative systematist. When species differ so trenchantly from one another, their degree of differentiation is better expressed by full generic separation than by forcing them into larger genera.

Relationships of Euprotomicrus

Euprotomicrus differs rather sharply from the other genera currently assigned to the Dalatiidae (Bigelow and Schroeder, 1948: 500). It contrasts with *Isistius* in having no subterminal notch in the caudal fin *(Isistius* has a shallow notch at the end of the body axis) ; the bases of the first dorsal and pelvic fins well separated vertically; the second dorsal basally elongated; the lower teeth strongly oblique instead of erect, with a deep incision on the outer edge and a broad shoulder wholly overlapping the next tooth outward; the dermal denticles more scattered and with roots extending out from the four corners. From *Dalatias* it differs in having the caudal axis much abbreviated and straight rather than upturned; the subterminal caudal notch obsolete, instead of well developed; the first dorsal fin behind instead of before the middle of the total length; the second dorsal fin with a much elongated base, not overlapping that of the pelvic fin; the lower teeth smooth-edged and strongly oblique; the dermal denticles quadrate and hollow-centered, without a posterior spine and without lengthwise ridges. From *Heteroscymnus (longus),* as described by Tanaka (1912: 102–105, pl. 26), it differs in fin structure in the same way that it differs from *Dalatias,* and further, in that the pectoral fins are rounded; the dentition, however, is similar; further differences are the conically rounded instead of depressed snout and the very large instead of small spiracles. From *Somniosus* it differs in approximately the same fin characters that separate it from *Dalatias,* and in having a much larger spiracle and many fewer teeth, of different form: the upper ones are more needle-like and the lower ones are much less strongly oblique; it differs further in having the center of the denticles pit-like instead of being elevated, with a posterior point.

From *Heteroscymnoides*, as described by Fowler (1934: 239, fig. 4; 1941: 273, fig. 10), it is separable by the form of the caudal fin, which has a horizontal axis and the epaxial part rather more instead of distinctly less expansive than the hypaxial part, and in having the second dorsal fin lower and longer on the base (in the structure of both these fins *Heteroscymnoides* is intermediate between the primitive forms *Dalatias, Heteroscymnus,* and *Somniosus,* and the more specialized *Isistius, Euprotomicrus,* and *Squaliolus). Euprotomicrus* further differs from *Heteroscymnoides* in the posterior displacement of the first dorsal fin, the much shorter and transversely rounded rather than depressed snout, the pitted instead of keeled and spiny denticles.

The characters of the diverse genera that have constituted the Dalatiidae suggest two main phyletic lines, corresponding with the main divisions of the accompanying analytical key, but the interpretation cannot be regarded as certain. The generic characters further suggest, by no means uniquely, a complicated phylogeny, in which similar features in different genera must have evolved independently. Thus the lower teeth presumably changed from erect to oblique in each of the two main groups. Primitive and specialized features are complexly associated in different combinations in the several genera—a common if not usual situation. No simple evolutionary tree (or "bush") can be reliably constructed on the basis of the available evidence. The apparent course of differentiation varies in accordance with the character on which attention is focused and there appears to be no securely objective basis on which to choose between the characters to be emphasized.

In the current classifications, reflected in Bigelow and Schroeder's treatment (1948), the presence or absence of spines in the dorsal fins is given prime and, we think, undue weight. The Squalidae and the Dalatiidae are separated almost solely on this basis. The virtual lack of other diagnostic characters and the strong indications that the spines have undergone obsolescence in more than one phyletic line render the family distinction seemingly artificial and unnatural. In some genera classed in the Squalidae, such as *Centroscymnus,* the dorsal spines are much reduced. Complete obsolescence of the spines would render *Centroscymnus* scarcely separable from *Somniosus,* a large and sluggish shark that might be expected to have lost this armature. Other genera referred to the Squalidae and the Dalatiidae are rather similarly paired, suggesting the multiple origin of the nominal group Dalatiidae. Further evidence on the unnaturalness of the Dalatiidae as currently defined is furnished by *Squaliolus,* which though classed in the Dalatiidae and by some even synonymized with *Euprotomicrus,* retains the first dorsal spine. *Squaliolus* seems to be a terminal element on a phyletic line quite different from that which seems to have led from *Centroscymnus* to *Somniosus* (see generic analysis). It would be extremely difficult to imagine the origin of all "Dalatiidae" from either *Somniosus*

or *Squaliolus*. For these reasons it is suggested that the Dalatiidae be fused with Squalidae. Echinorhinidae, then, should likewise be synonymized with Squalidae. Pending thorough morphological studies and a general revision of the squaloids, the two groups thus demoted from family rank may perhaps be retained tentatively as subfamilies, Dalatiinae and Echinorhininae.

That *Euprotomicrus* is a highly modified terminal product of specialization is indicated by the characters that give this genus such an unusual appearance (p. 161), and by the transverse mouth, with very long lateral grooves; the great modification of the teeth, with extreme dimorphism in the two jaws; the peculiar, pitted, quadrate denticles; the great vertical expansion of the upper caudal lobe and the marked abbreviation of the lower lobe; and the greatly reduced number of vertebrae.

OUTLINE OF RELATIONSHIPS

1a { 2a *(Dalatias)*
2b { 3a *(Heteroscymnus)*
3b *(Somniosus)*

1b { 4a *(Isistius)*
4b { 5a *(Heteroscymnoides)*
5b { 6a *(Squaliolus)*
6b *(Euprotomicrus)*

ANALYTICAL KEY TO THE KNOWN GENERA OF DALATIINAE

1.

a. Caudal axis strongly upturned; epaxial part of caudal fin little expanded; subterminal caudal notch strongly developed. Mouth more arched and lateral grooves shorter and shallower. Spiracle small. Larger, about 30 cm. at birth and commonly longer than 1 meter as adult. Chiefly in boreal and temperate seas; probably largely demersal 2

b. Caudal axis scarcely upturned or (in *Heteroscymnoides)* weakly upturned; epaxial part of caudal fin much expanded (moderately so in *Heteroscymnoides);* subterminal notch in caudal fin obsolescent (weak in *Isistius).* Mouth essentially transverse; lateral grooves very long and deep. Spiracle large. Small size, unknown over 50 cm., and most specimens well under 30 cm. Chiefly in warm seas; probably largely pelagic 4

2.(1a)

a. Lower teeth erect and serrate ..... *Dalatias*
b. Lower teeth directed outward and smooth-edged 3

3.(2b)

a. First dorsal fin larger than second and with angular apex; tip of pectoral angular ..... *Heteroscymnus**
b. First dorsal fin no larger than second and with rounded apex; tip of pectoral rounded ..... *Somniosus*

* *Heteroscymnus* may differ from *Somniosus* in other characters, such as dentition or denticle structure, that were not fully described by Tanaka. If it does not, *Heteroscymnus* may be reduced to subgeneric rank or perhaps to the synonymy of *Somniosus.*

4.(1b)

a. Lower teeth erect. First dorsal fin more displaced backward, the end of its base over front part of pelvic base. Dorsal fins subequal. Subterminal notch in caudal fin definitely evident, though small. (Denticles quadrate, with median pit, but without root-like processes. Fins not clear-edged.).... *Isistius*

b. Lower teeth strongly bent outward. End of base of first dorsal fin well in advance of pelvic insertion. Second dorsal longer-based than first. Subterminal notch of caudal obsolescent..... 5

5.(4b)

a. Denticles triangular, keeled, ending in a spiny point. Base of second dorsal not more than one-half longer than base of first dorsal. Caudal axis moderately upturned; epaxial part of caudal distinctly less expansive than hypaxial part. Snout depressed. Fins entirely blackish, not clear-edged. (First dorsal without spine, beginning far in advance of middle of total length, over pectoral base. Snout much produced.)..... *Heteroscymnoides*

b. Denticles quadrate, with central pit and with roots at the four corners. Base of second dorsal much more than twice as long as base of first dorsal. Caudal axis scarcely upturned; epaxial part of caudal about as greatly expanded as hypaxial part. Snout scarcely depressed. Fins blackish at base, transparent outward..... 6

6.(5b)

a. First dorsal with a definite spine, beginning before middle of total length, much nearer pectoral than pelvic base. Snout much produced and sharper ..... *Squaliolus*

b. First dorsal without trace of spine, beginning behind middle of total length, much nearer pelvic base than pectoral base. Snout blunt and broadly rounded. (Other differences outlined on p. 161.)..... *Euprotomicrus*

Description of Specimen

The body is essentially cylindrical in cross-section. In the region of the gill slits and in the anterior part of the trunk, where the area of cross-section is greatest, the width of the body equals its depth. The snout at its base is about 0.1 wider than deep. Toward the base of the pelvic fins the ventral surface becomes flattened and the width becomes restricted to about 0.7 the depth. Behind the end of the second dorsal base the body becomes depressed. Behind the pelvic fins a rectangular cross-section is gradually assumed, owing to the flattened lower and upper surfaces and the development of a ridge along the posterior part of the lateral line and of another ridge along the ventrolateral edge of the caudal peduncle. As the upper of these two ridges begins more anteriorly, the cross-section in the region below the second dorsal base, and to a slight degree farther forward, is somewhat pentagonal. Between the dorsals and in front of the first dorsal is a weak ridge along the midline. Between the anus and the base of the

lower caudal lobe is a pair of moderately conspicuous grooves, rather close together. There are no precaudal pits. The distance from the tip of the caudal fin to the front of the anus is contained about 1.85 times in the distance thence forward to the tip of the snout. The greatest depth is contained 7.4 times in the length to the subcaudal origin. The least depth of the caudal peduncle is contained 1.6 times in the orbit (excluding the notches).

The ventral contour is nearly straight from the mouth to the caudal base. The dorsal contour curves gradually downward from above the end of the pectoral fin to the base of the caudal. As seen from the side, the head is almost bullet-shaped, with the snout very broadly rounded. As seen from above or below, the lateral contours converge forward in nearly straight lines to the rear of the nostrils, where the width is approximately equal to the preocular length. The outlines are strongly concave between the nostrils and the almost hemispherical tip of the snout. The snout is relatively short in front of the eye but moderately long in front of the mouth: the preocular length is contained 1.7 times in the preoral length, which approximates the distance from the middle of the mouth to the first gill slit.

The nostrils are unusually far forward and are more nearly lateral than ventral. As seen from the front, their axes converge strongly downward, so that, if extended to a common meeting, they would approximate an equilateral triangle. The least distance between the nostrils, at the ventral end, is approximately 0.4 the greatest distance between the outer edges of the narial pores. These pores, which form the upper end of the nostrils and are directed almost straight forward, are oval in cross-section, with a vertical height about two-thirds the transverse diameter, which is about two-thirds the length of the pupil. Just below the pore, the posterior rim of the nostril is inturned as a blunt flap, which is overlain by the almost hook-like process at the upper end of the thin narial valve. The total height of the nostril approximates 0.5 the preocular length of the snout, and is about 0.5 greater than the least internarial distance. As seen from below, the nostrils form an angle of 130°. As seen from the front, they form an angle of 95°.

The subcircular eye cannot be covered by eyelids. The pupil is round. The horizontal diameter of the cornea is about 0.1 greater than the vertical. The upper orbital margin is formed by two lines diverging at 140°, each ending in a notch, of which the one in front is smaller and shallower than the one just behind the upper third of the eyeball. The lower margin of the orbit is approximately semicircular. The surfaces of the eyes converge downward at an angle of about 38°. The eye is bisected by the body axis. The interorbital is strongly convex.

The spiracles are very large. The width (height) is about equal to the length of the pupil, is about 0.5 the orbital diameter, excluding the notches, is about two-thirds the least distance between orbit and spiracle, and is

about 0.25 the interspiracular distance. Their axes converge upward at an angle of 72°. They are located about midway, vertically, between the eye and the dorsal profile. Each spiracle is roughly semicircular, with the posterior edge nearly straight. Toward the front is a conspicuous crescentic septum, fimbriate on its posterior edge.

The gill slits are excessively short. The second and longest is approximately 0.5 as high as the spiracle. Posteriorly the height decreases to the fifth, which lies just in advance of the insertion of the pectoral fin. This last slit is hardly more than a pore, less than 0.25 the height of the spiracle.

The main part of the mouth is an almost transverse slit, with the perpendicular only about 0.1 the chord, which about equals the preocular length. From each angle there extends backward and slightly outward a deep groove, which is contained about 1.4 times in the width of the mouth proper. Around the corner of the mouth is a thick fold, completely hidden when the mouth is closed. The mandibular part of this fold is very short and weakly developed, whereas the anterior part is a very conspicuous soft fleshy structure lying in a deep recess, which is continued backward as the posterior groove and forward as a cavern. Within the corners of the mouth the suborbital skin forms a broad semicircle before it becomes attached toward the midline. From this region of attachment a fold of skin separates the upper jaw from the thick fold previously described. There is a corresponding but much thinner fold against the lower jaw. The pocket immediately in front of the upper jaw is deeper than the corresponding mandibular pocket, and has a fringed edge. The posterior grooves of the mouth converge to an angle of about 40°.

The teeth are extremely unlike in the two jaws. Those in service in the upper jaw form about 4 rows, with the teeth of the adjacent rows alternating, so that the tooth arrangement is in quincunx. Each tooth is narrowly triangular and needle-pointed and has a narrowly forked root. In the lower jaw, in contrast, only a single series functions. The lower teeth are bent outward, so that those near the center of the jaw diverge at an angle of about 43°. The outer exposed edge is weakly convex and only slightly oblique. The inner edge is strongly oblique and is slightly concave, especially toward the sharp tip. These lower teeth are very much compressed and have a flat outer surface, contrasting with the rounded outer surface of the much narrower upper teeth. The inner edge of each crown contacts the base of the crown of the next tooth inward and is overlapped by the strong, rather pointed shoulder of that tooth. The lower teeth number 11+1+10 (the 11 on the left side include a very small one in the rear). There is no trace of denticulations on either upper or lower teeth.

The denticles are of two types, both of which are quadrate, with incurved edges, laterally projecting roots from the corners, and a deep hollow center. They agree in showing no obvious distinction between pedicel and blade.

In about every fourth to sixth row of small denticles is one about 2 or 3 times as long on each side. These larger denticles have strongly concave margins and, in addition to the central pit, a pit in each angle. Some have additional pits around the periphery of the median one. To the naked eye, the smaller denticles are scarcely visible, but the large ones look like minute scattered warts. The pattern of the denticles is approximately uniform over the body and head.

The lateral-line pores are rather irregularly spaced. There are 60 between the verticals from the pectoral insertion and the origin of the upper caudal lobe. The series continues for about 8 pores along the anterior half of the caudal axis. The lateral line is continued forward as a series of 19 pores to one that lies just above the spiracle. The pore just anterior and inside the last-named pore is the outermost in a cross-commissure of 9. Near the midline, just in advance of this commissure, is a pair of well-separated pores. Anterior to the outermost pore of the commissure a slightly sigmoid row of 22 pores extends to opposite the front of the eye. The same series is continued forward, curving inward, toward the tip of the snout. On the interorbital region, inside the supraorbital row on each side, is a considerable scattering of pores. Pores are also scattered behind the upper posterior part of the infraorbital series, and across the lower part of the snout, between the middle sections of these series. The preorbital file, however, is simple. On the lower side of the snout the pores tend to be concentrated in a zigzag cross-commissure and in a rather V-shaped file behind the inner tips of the nostrils.

There are no obvious luminous organs. In life, however, the skin was very slimy and it is not impossible that the mucus may be luminous.

There is no trace of spines in any of the fins, either in external view or on the X-ray plates. The dorsal fins are very dissimilar in size. The base of the anterior fin is hardly as long as the eye. It begins midway between the margin of the caudal fin and the middle of the eye (it is indicated in the figure about one pupil-length too far forward). The upper-anterior angle of this fin is very broadly rounded and the upper-posterior angle is sharply pointed. The height of the fin is about twice its basal length. The interdorsal space is 0.3 longer than the distance between the end of the second dorsal base and the beginning of the upper caudal lobe. The base of the second dorsal is about thrice as long as that of the first, and in depressed length more than twice as long. Its upper-anterior angle is very broadly rounded and its posterior tip is sharply pointed. The vertical from the origin of the first dorsal is 3.5 times as far from the end of the pectoral base as it is from the pelvic insertion. The origin of the second dorsal is approximately over the posterior end of the pelvic base. The distance from the tip of the second dorsal to the beginning of the upper caudal lobe is approximately equal to the length of the orbit, including the notches.

The caudal fin is nearly symmetrical, with both lobes greatly expanded. The fleshy axis expands before its middle to a width about 0.5 greater than the least depth of the peduncle. The posterior, acuminate tip of the urostyle reaches the margin on the lower posterior edge of the upper lobe. There is, however, little trace of a subterminal notch. The vertical expansion of the upper lobe approximately equals that of the lower, but since the upper lobe begins a pupil's length farther back and has a more oblique front edge, about half its area is behind the tip of the lower lobe. The angle formed by the slightly convex front edges of the lobes is 79°. Each lobe is broadly rounded, with a weakly convex posterior edge. The margin of the lower lobe slopes upward and slightly backward; that of the upper lobe, upward and slightly forward. The upper-posterior margin of the lower lobe, below the end of the urostyle, is rather evenly and deeply concave. The distance between the tips of the lobes is nearly 0.2 greater than the distance between the origin of the lower lobe and the tip of the urostyle.

The pectoral fin in ventral view forms roughly an equilateral triangle, with the anterior and posterior edges moderately convex and the lower-posterior angle broadly rounded. The upper or anterior half of the fin is approximately horizontal; the lower, or posterior, part, arched downward. The fleshy pelvic bases are approximately flat and horizontal. The pelvics are elongate basally, very broadly rounded at the outer-anterior corner, and very sharply pointed on the inner-posterior angle. The outer edge is concave just in advance of the sharp posterior tip. The fins are in contact over and behind the anus, in a straight line about two-thirds the greatest length of the fins. The tips extend to behind the vertical from the middle of the second dorsal base. Just behind the anus, between the inner ends of the pelvic bases, is a pair of valve-like flaps.

Perhaps in correlation with the dwarf size, the segments are very few. Between the front edges of the paired fins about 22 muscle bands are indicated by slightly depressed and slightly darkened lines crossing the belly. The myomeres are very weakly angulated on the sides and on the belly. The individual vertebrae, clearly evident in the X-ray photograph (plate VI), are elongate and much constricted medially so that the adjoining halves form spindles, much as in a teleost. There are only 48 between the head and the origin of the upper caudal lobe. Along the axis of the caudal fin the vertebrae become much reduced and difficult to see in the X-ray photograph. There are 6 vertebrae anterior to the insertion of the pectoral fin, 21 between the insertions of the paired fins, and 21 between the pelvic insertion and the origin of the upper caudal lobe. The contrast between these vertebrae and the disc-like vertebrae of most sharks is very great, but the condition in *Euprotomicrus* is approached by that in certain other squaloid sharks (Hasse, 1879–1885).

The fins are only partly covered with denticles. The pectoral has a thick covering on its basal third to two-fifths, with a further extension outward near the front edge. The pelvic has denticles only on the swollen fleshy base. The caudal is well covered over the fleshy axis and outward over two-thirds to one-half of each lobe. The dorsals are almost entirely devoid of denticles, except at the extreme base. Beyond the area covered by denticles, the fins are extremely thin and flexible and clearly show the ceratotrichia.

In the water this little shark appeared brown, but when brought on deck seemed blackish. Some myctophids exhibit a similar apparent color change. In alcohol the specimen is blackish, with purple and brown sheens. The blackish body color extends over the denticle-covered part of the fins, with diffusion somewhat farther out. The outer edges of the fins, however, are crystal clear, in a pattern well shown in the figures. The urostyle is black to its slender tip. The concealed parts of the mouth are whitish, as is also its anterior exposed margin medially. The thin outer part of the narial valve is clear of pigment.

When seen at the surface the little shark was swimming slowly with an undulatory movement, progressing in an approximately constant direction as though it was not especially attracted by the light. A first miss with the dip-net did not seem to frighten it. It showed extremely little activity when picked out of the net and even when placed in formalin did not become very active. It was very slippery, owing to a profuse coating of slime. Quantities of mucus were exuded onto the net.

Proportional Measurements

The measurements are expressed in thousandths of the total length (233 mm.). They were made before the specimen was transferred from formalin to alcohol. In comparison, proportions for a few critical measurements are given for the holotype, 192 mm. in total length, on the basis of measurements made for us through the kindness of Dr. Léon Bertin.

Body.—Predorsal length, from tip of snout to extreme front edge of dorsal base, 527 (521 in type). Distance between dorsal origins, 152 (167 in type). Interdorsal space, 122. Origin of second dorsal to margin of upper caudal lobe, 314. Tip of second dorsal to caudal margin, 190. Pectoral insertion to dorsal origin, 300 (312 in type). Prepectoral length, 245. Prepelvic length, 614. Between insertions of paired fins, 379. Greatest body depth, 116. Least depth of caudal peduncle, 21. Greatest body width, 117. Width of caudal peduncle at front of caudal fin, 22.

Head.—Length to nearest point of first gill slit, 189 (177 in type). Width between first gill slits, 111. Preocular length of snout, 63. Preoral length of snout, 102. Snout tip to outer end of nostril, 34. Nostril length,

including dorsal pore, 30. Least internarial width, 21. Width between inner edges of dorsal pores of nostrils, 40. Width between tips of narial flaps, 53. Least distance from nostril to orbit, 33. From nostril to mouth, 72. Front of mouth to line joining ends of gape, 52. Width between outer edges of concealed lips, 67. Width between ends of oral grooves, 92. Orbit to end of oral groove, 60. Orbital notch to end of oral groove, 63. Least suborbital width, 24. Orbit length, between inner edges below notches, 36. Between extreme ends of orbital notches, 46. Orbit height, 30. Fleshy interorbital width, 82. Width between orbits, ventrally, 68. Least interspiracular distance, 69. Postorbital notch to spiracle, 30. Between outer-ventral and inner-dorsal ends of spiracle, 20. Anteroposterior width of spiracle, 13. Spiracle to end of oral groove, 38. Spiracle to pectoral insertion, 110. Between front of first and fifth gill slits, 50. Longest gill slit, 16.

Fins.—First dorsal: base, between extreme ends, 29; origin to upper-anterior tip, 46; upper-posterior edge, 31; lower-posterior edge, 37. Second dorsal: base, 86 (88 in type); origin to upper-anterior tip, 39; upper edge, 104; lower-posterior edge, 50. Caudal: upper lobe, extreme origin to farthest point, 142; lower lobe, origin to tip, 120; dorsal origin to tip of urostyle, 129; dorsal origin to nearest point on margin, 102. Pectoral (appressed against body): base, 39; insertion to upper-posterior tip, 98 (89 in type); to lower-posterior tip, 101; posterior edge, 85; extreme width, 91; lower posterior edge, 71. Pelvic: base, 68; insertion to outer-anterior tip, 55; outer-posterior edge, 72; inner-posterior edge, 48.

Summary

A very peculiar small shark collected at the surface over deep water nearly 500 miles off California is identified as *Euprotomicrus bispinatus* (Quoy and Gaimard). It is the second specimen of the genus known from the Pacific Ocean. *Euprotomicrus* is regarded as monotypic, since *Squaliolus,* also treated as monotypic, is interpreted as generically distinct. *Euprotomicrus hyalinus* Eigenmann and *Squaliolus sarmenti* de Noronha are synonymized with *E. bispinatus* and *S. laticaudus* Smith and Radcliffe, respectively. *Euprotomicrus* is a highly modified squaloid shark referable to the Dalatiidae as currently defined. Generic relationships within this group are rendered uncertain because of convergent evolution. Many species show primitive and specialized features in confusing combinations. The validity of the separation of the Dalatiidae from the Squalidae is discounted, for the dorsal spines seem to have become lost on several phyletic lines. Echinorhinidae is also synonymized with Squalidae. Provisionally these groups are retained as subfamilies, Dalatiinae and Echinorhininae. The dalatiine genera seem to form two main lines (see analytical key, p. 164). The new specimen is described and its measurements are listed.

LITERATURE CITED

Bigelow, Henry B., and William C. Schroeder

1948. Sharks. Fishes of the western North Atlantic (Memoirs Sears Foundation for Marine Research), 1:59–546, figs. 6–106.

de Noronha [misprinted di Noronha], Adolfo César

1926. A new species of deep water shark (Squaliolus sarmenti) from Madeira. Annals Carnegie Museum, 16:385–389, pl. 35.

Duméril, Aug.

1865. Histoire naturelle des poissons ou ichthyologie générale. Vol. 1, Élasmobranches plagiostomes et holocéphales ou chimères, pt. 1:1–720.

Eigenmann, Rosa Smith

1893. Description of a new species of *Euprotomicrus*. Proceedings of the California Academy of Sciences, 2nd Ser., 3:35.

Fowler, Henry W.

1934. Descriptions of new fishes obtained 1907 to 1910, chiefly in the Philippine Islands and adjacent seas. Proceedings of the Academy of Natural Sciences of Philadelphia, 85, 1933:233–367, figs. 1–117.

1941. Contributions to the biology of the Philippine Archipelago and adjacent regions. The fishes of the groups Elasmobranchii, Holocephali, Isospondyli, and Ostariophysi obtained by the United States Bureau of Fisheries Steamer "Albatross" in 1907 to 1910, chiefly in the Philippine Islands and adjacent seas. Bulletin of the United States National Museum, 100, vol. 13:i–x, 1–879, figs. 1–30.

Garman, Samuel

1913. The Plagiostomia (sharks, skates, and rays). Memoirs of the Museum of Comparative Zoology at Harvard College, 36:i–xiii, 1–515, pls. 1–77.

Hasse, C.

1879–85. Das natürliche System der Elasmobranchier auf Grundlage des Baues und der Entwicklung ihrer Wirbelsäule — Ein morphologische und paläontologische Studie. Gustav Fischer, Jena. Allgemeiner Theil, 1879:i–ix, 1–76, figs. 1–6, 2 diags., pls. 1–2. Besonderer Theil, 1, 1882:1–94, pls. 1–12; 2, 1882:95–179, pls. 13–23; 3, 1882:180–285, pls. 24–40. Ergänzungsheft, 1885:1–27, 2 diags., 1 pl.

Maul, G. E.

1949. Lista sistemática dos peixes assinalados nos mares da Madeira e índice alfabético. Vertebrados da Madeira, 2 (Peixes), de Adolfo César de Noronha e Alberto Artur Sarmento: 135–181.

Müller, J., and J. Henle

1841. Systematische Beschreibung der Plagiostomen. Von Heit & Co., Berlin: i–xxii+4, 1–200, 60 pls.

PHILLIPPS, W. J.

1927. Bibliography of New Zealand fishes. Bulletin of the New Zealand Marine Department of Fisheries, 1:1–68.

1928. Sharks of New Zealand: No. 2. New Zealand Journal of Science and Technology, 10:221–226, figs. 1–8.

QUOY, JEAN RENÉ CONSTANTIN, and PAUL GAIMARD

1824. Remarques sur quelques poissons de mer; description des poissons. Voyage autour du monde exécuté sur les corvettes de S. M. "L'Uranie" et "La Physicienne" pendant les années 1817–20:182–401, pls. 1–96.

SMITH, HUGH M.

1912. The squaloid sharks of the Philippine Archipelago, with descriptions of new genera and species. Proceedings of the United States National Museum, 41:677–685, figs. 1–4, pls. 50–54.

TANAKA, SHIGEHO

1912. Figures and descriptions of the fishes of Japan, including Riukiu Islands, Bonin Islands, Formosa, Kurile Islands, Korea, and southern Sakhalin, 6:87–108, pls. 26–30.

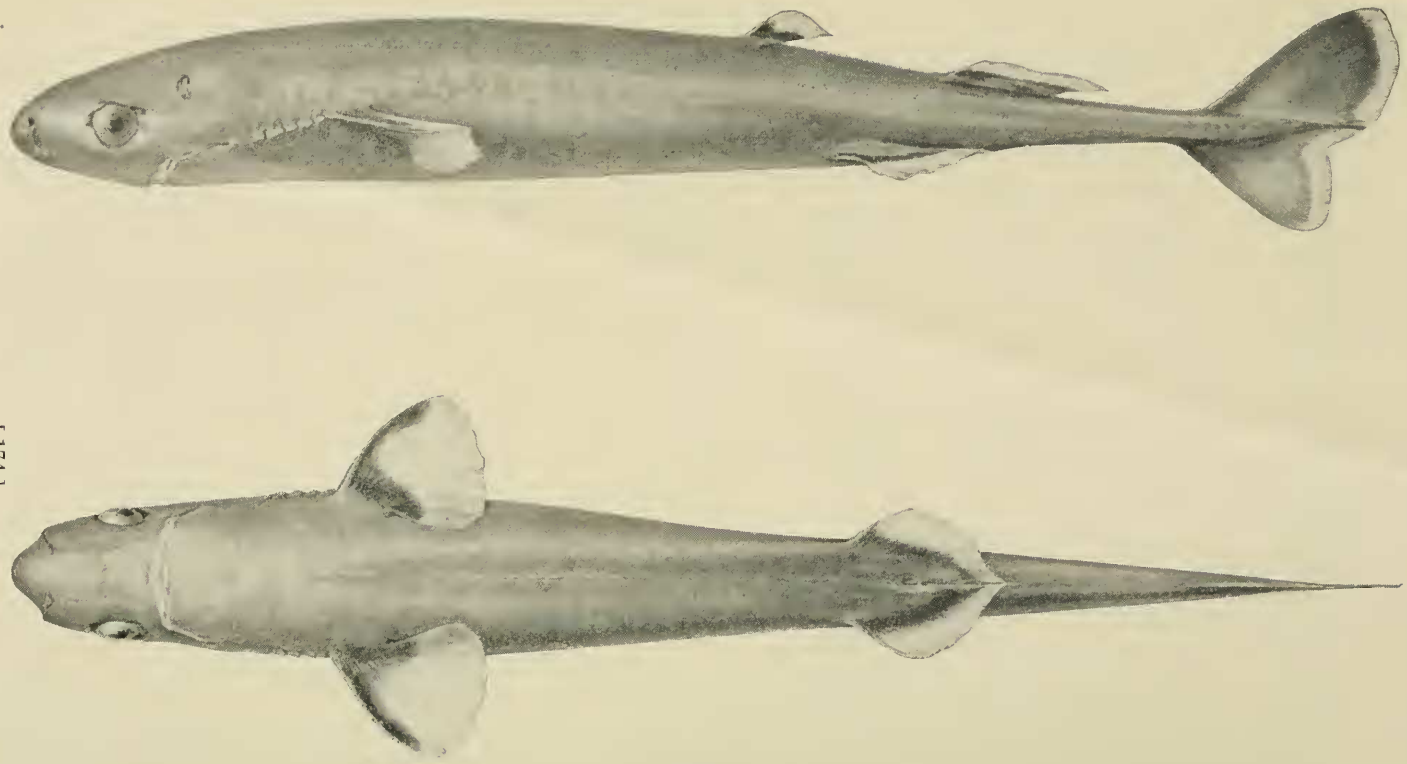

PLATE IV

FIGURE 1. Lateral view of a 233–mm. female specimen of *Euprotomicrus bispinatus*, a peculiar little shark captured at the surface nearly 500 miles off California. All drawings by Alma Froderstrom.

FIGURE 2. Ventral view of the same specimen.

PLATE V

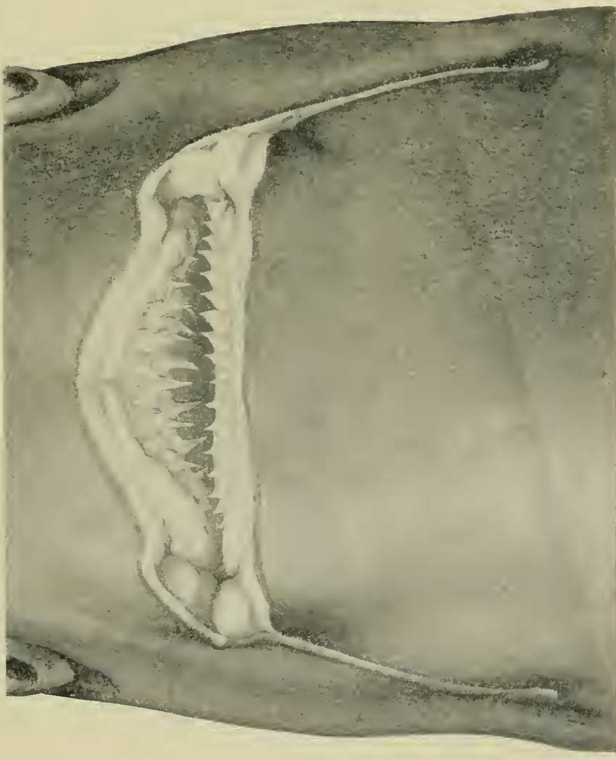

FIGURE 1. Mouth and teeth of the same specimen.

FIGURE 2. Top of head of the same specimen.

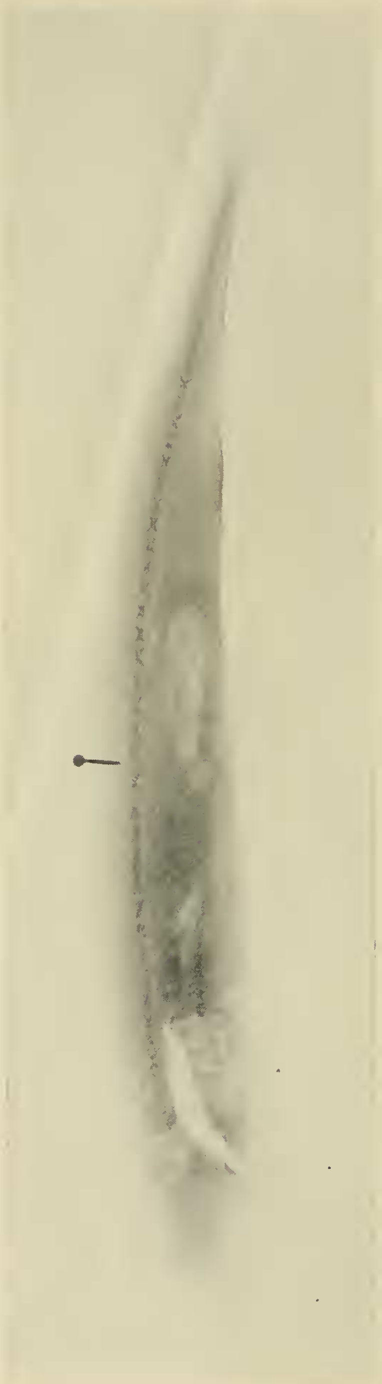

PLATE VI

X-ray photograph of the same specimen, to show, in particular, the vertebrae, which are elongate and much constricted medially, so that the adjoining halves form spindles. Photo by J. L. McHugh.